Thickness Measurement for UF_4 Targets

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In the production of heavy elements the pertinent cross section varies rather dramatically with the projectile energy. An optimal beam energy for production of heavy elements has to be chosen according to target thickness. The targets used in the $^{48}Ca+^{238}U$ reaction were UF_4 evaporated on a Al backing. Typical high beam intensity of ~1 pμA deposits heat on the target and may induce a change in target morphology. Nine banana-shaped target frames were mounted on a wheel rotating at 6 Hz in order to dissipate the heat. The target thickness has been deduced by weighing the target after the evaporation and dividing the weight of UF_4 by a masking area. Owing to a peculiar shape of the target, the target thickness did not appear to be uniform across the whole range. We have measured 7 segments of each Al foil before evaporating UF_4 in a MG wheel by alpha spectrometry using a 3-point source. The source consists of ^{239}Pu, ^{241}Am and ^{244}Cm. The schematic layout is shown in Fig. 1. The thickness of a Al foil has been deduced using the stopping power of alpha particles in Al [1,2]. Typical Al thickness turned out to be 2.2±0.2 μm.

UF_4 targets evaporated on a Al backing have been measured by both the 3-point source and direct alpha counting without the source. The U isotopic composition of the target has been deduced by the direct alpha counting. The U isotopes in the target were ^{234}U, ^{235}U and ^{238}U, whose α-decay energies and intensities are listed in Table 1. The α-decays of 4.604, 4.722 and 4.775 MeV cover almost total decay intensity of ^{234}U, even though there are α-decays at lower energies that might not be resolved from those in ^{235}U and ^{238}U. The alpha energies of ^{235}U range from 4.150 to 4.596 MeV, and are 4.038, 4.151 and 4.198 MeV for ^{238}U. The major concern is that 4.151-MeV alpha particles are emitted from all three U isotopes and 4.596 MeV of ^{235}U is too close to 4.604 MeV of ^{234}U. One can choose the region ranging from 4.300 to 4.430 MeV where most alpha particles are emitted mainly from ^{235}U and the corresponding decay intensity covers ~72%. Its lower-energy and higher-energy alpha particles interfere with those from ^{234}U and ^{238}U, respectively. With the intensity consideration, about 89% of all the alpha particles have been deduced to be from ^{238}U. This value has been used to deduce the target thickness related to ^{238}U.

Several segments of each UF_4 target have been measured by the direct alpha counting and the corresponding measured thicknesses have been fitted with a normal distribution. A typical thickness distribution is shown in Fig. 2. As shown in Fig. 2, the thickness in the middle (Segment 5) was thickest and became thinnest at the edge (Segment 8). Variations in thickness over the whole range of each target have been observed to be 20-50%. We have deduced the overall target thickness of each target by integrating its corresponding fitted distribution over the entire range. The thickness of a UF_4 target deduced by weighing, averaging the measured values, and integrating is 397, 384, and 383 μg/cm^2, respectively. Three values seem to agree well within a 4% variation.

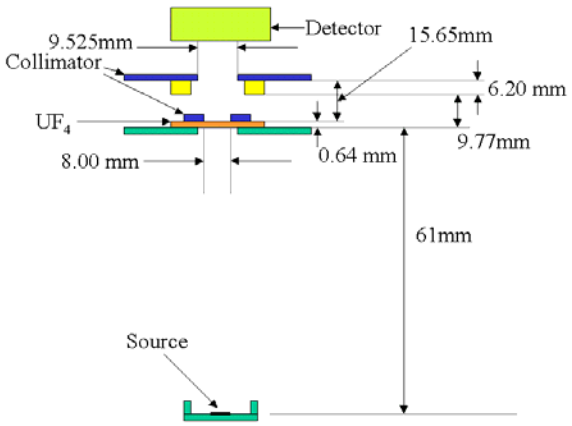

FIG. 1: Layout for target thickness measurement

Table 1: α-decay energies and intensities [I_α>0.001] from ^{234}U, ^{235}U and ^{238}U.

E_α (MeV) in ^{234}U	E_α (MeV) in ^{235}U	E_α (MeV) in ^{238}U
4.109, 4.151, 4.276, 4.604[0.0020], 4.722[0.2842], 4.775[0.7138]	4.150[0.009], 4.215[0.057], 4.219[0.009], 4.271[0.004], 4.295, 4.366[0.17], 4.398[0.55], 4.414[0.021], 4.435[0.007], 4.502[0.017], 4.556[0.042], 4.596[0.050]	4.038[0.00078], 4.151[0.209], 4.198[0.790]

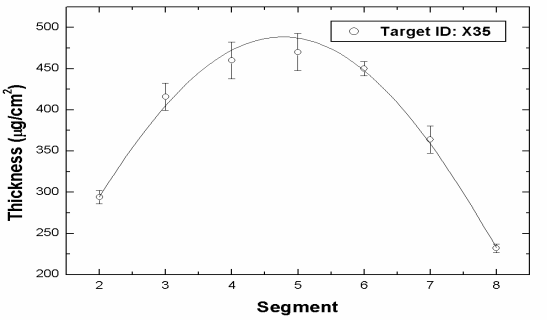

FIG. 2: Typical thickness distribution of a UF_4 target. Open circles refer to measured thickness and solid line to fitting with the normal distribution.

REFERENCES

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